Computer simulation

- From class web page in lab sections open "**PhET Gas Laws Simulation**"
- Launch the simulation

  URL:

  http://phet.colorado.edu/en/simulation/gas-properties

-OR-

- Google: "gas law PhET simulation"

Before you answering questions…

That you can…

1. Add both heavy and light gases to the container

2. Adjust the temperature of the container while holding the pressure constant

3. Decrease the volume of the container

PhET Gas Simulation Turn In

Answer all question on separate sheet of paper labeled “PhET Gas Simulation”

Compose a properly formatted email to send graphs saved to a single sheet as a pdf. and forward to Mr. Golden by 12:30pm 6.Mar.2018. Save pdf. as follows, “**pX.FirstLast.phetgaslaws1718**”

BELL WORK, 2-Mar-2018

Write a balanced equation for the reaction below:

Zinc and hydrochloric acid react to from Zinc (II) Chloride and Hydrogen gas

In series of trials a student recorded the following data when reacting Zinc and Hydrochloric acid

	Trial A	**Trial B**
Mass of Zinc (M.M. 65g/mol)	5.00g	10.0g
Moles of Zinc		
Mass of HCl (M.M. 36g/mol)	15.0g	18.0g
Moles of HCl		
Mole ratio of zinc to HCl		
What is the Limiting reagent		
Moles of H_2 gas formed		

Agenda

Pressure units and Kelvin

Objective

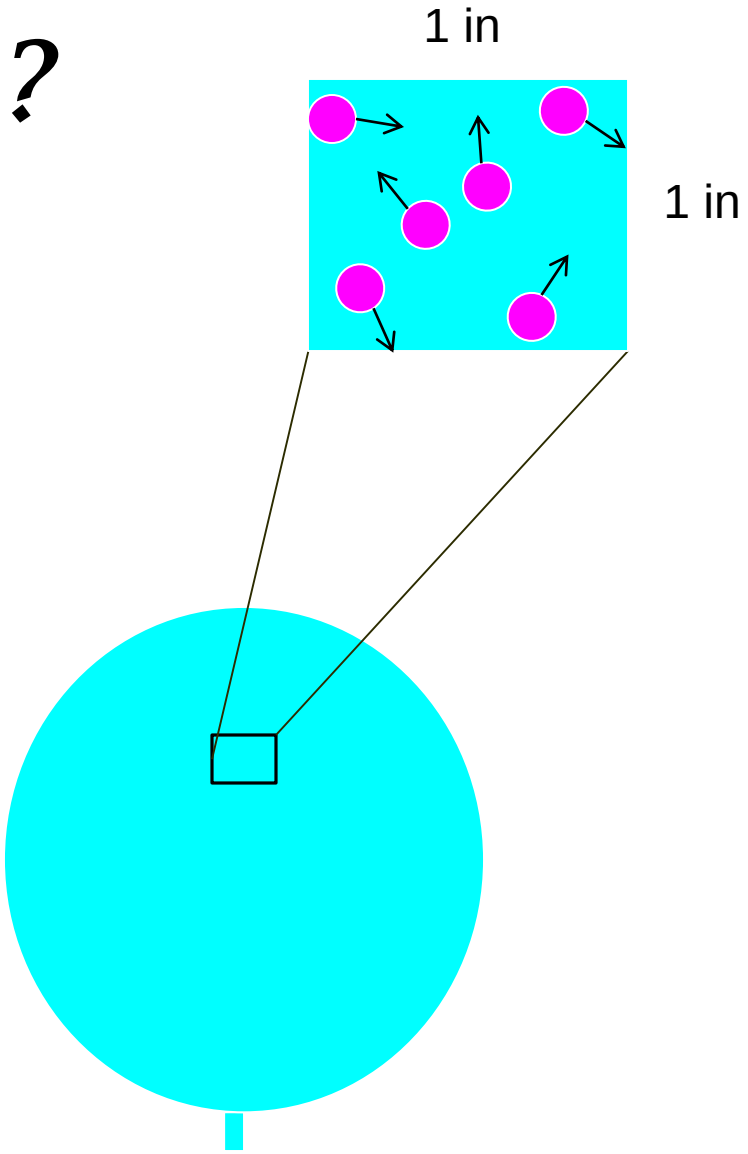
You will be able to convert between different pressure units.

What is pressure?

$$\text{Pressure} = \frac{\text{Force}}{\text{Area}}$$

Units of Pressure

1 pascal (Pa) = 1 N/m²



1atm =

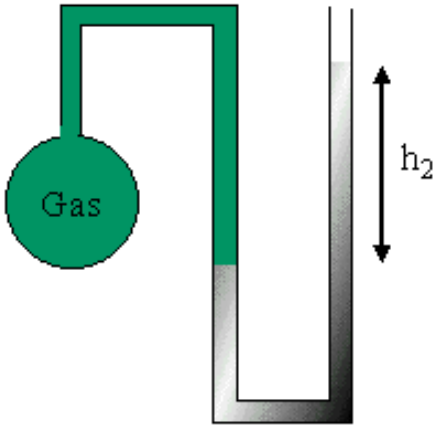
760 mmHg =

760 torr =

101.325 kPa =

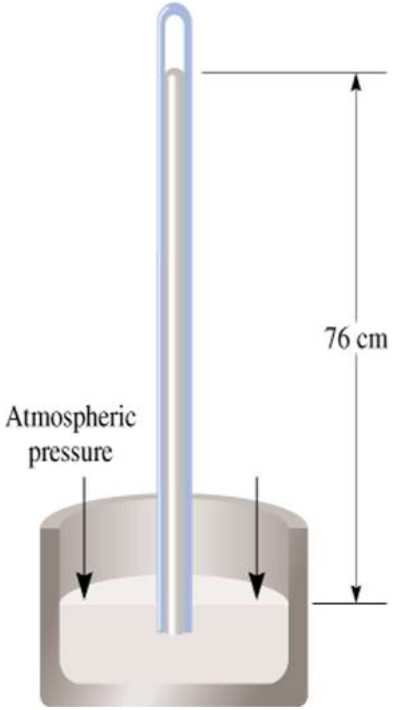
14.7psi

How do we measure pressure?



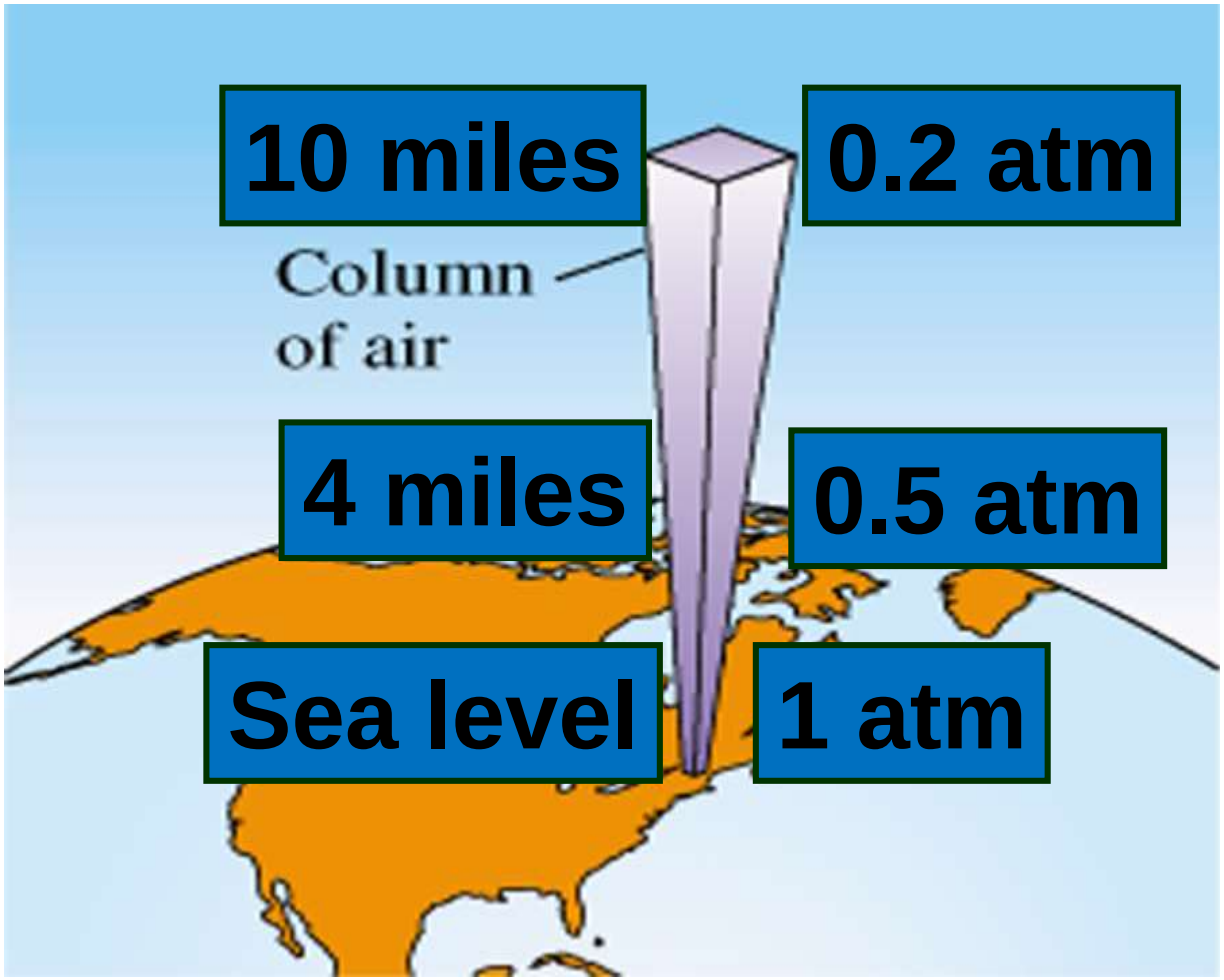
A <u>manometer</u> uses a U-shaped tube of liquid to measure pressure differences on either side of the liquid

A <u>barometer</u> uses the height of a column of mercury to measure gas pressure in mmHg



https://www.youtube.com/watch?v=EkDhlzA-lwI

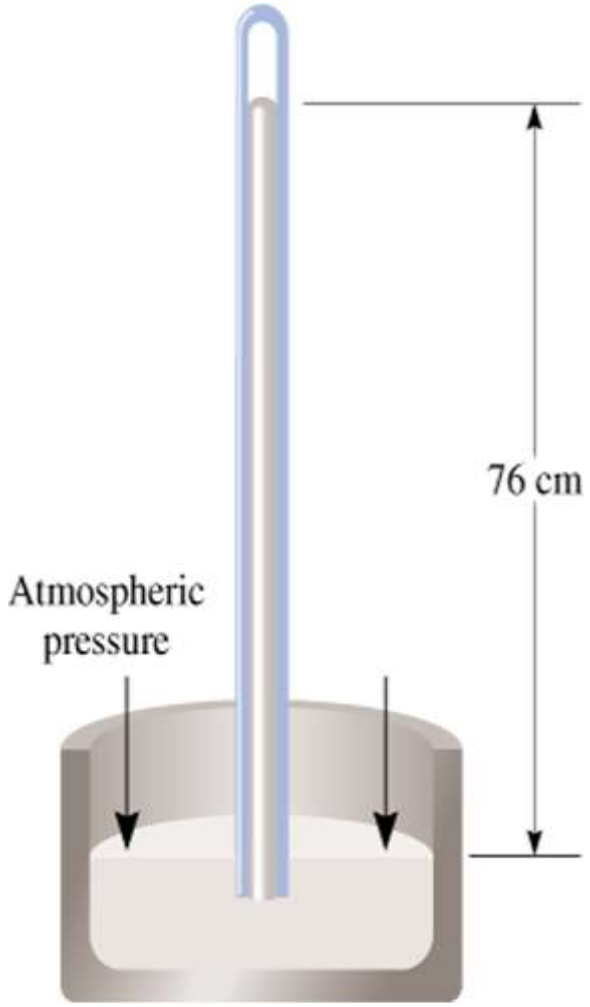
What is the pressure in mmHg at sea level?
What is the pressure in Pascals at sea level?



Try this…

Convert:

1. **727 mmHg into kPa**
2. **52.5 kPa into atm**
3. **0.729 atm into mmHg**
4. **522 torr into kPa**
5. **800.0 mmHg into atm**
6. **495Pa into mmHg**



Barometer

Standard Temperature and Pressure

Standard temperature and pressure (**STP)** refers to nominal conditions in the atmosphere at sea level. This value is important to physicists, chemists, engineers, pilots and navigators. Why?

Temperature = 0° C or 273K
Pressure = 1atm

All temperature must be converted to Kelvin

To convert ^{0}C → K

$$T\,(\mathrm{K}) = t\,(^0\mathrm{C}) + 273$$

To convert K→ ^{0}C

$$T\,(^0\mathrm{C}) = t\,(\mathrm{K}) - 273$$

Why is the Kelvin scale used exclusively in gas law calculations?

BELL WORK 5-Mar-2018

~~Long onto a computer and sign into Mozilla or Chrome.~~

~~Go to class web page and open the lab section.~~

~~While you wait for computer to load complete the following:~~

Solve the following equation for V_2:

$$P_1V_1 = P_2V_2$$

What is the equivalent pressure for a tank of compressive gas at 2.8atm if you are asked to report value in mmHg?

Computer simulation

Agenda

Objective

To explore how gases are affected by different variables using a computer simulation

BELL WORK 5-Mar-2018

Draw three different balloons with air particles in them

1. **One full of gas at room temperature**

2. **One full of gas at 0 °C (~32 ° F)**

3. **One full of gas at 50 °C (~122 ° F)**

- Using dots show particles inside each of the balloons (Keep number of particles (“n” moles) constant between Balloons)

- Use arrows to indicate how fast they are moving (longer arrow = faster)

- Rank the balloons from lowest to highest pressure

EQ: Where else in life do we make assumption to simplify a situation?

Agenda

Gas properties and the KMT

Objective(s)

To explain properties of gases using the kinetic molecular theory

To explain to a group of peer one of the tenitis of the KMT of gasses.

Try it

Using the gas law formula for changing volume and temperature while holding moles and pressure constant solve for T_2.

$$\frac{V_1}{T_1} = \frac{V_2}{T_2}$$

Gas Law Problems #1

#1-16 due (show all work) 7Mar2018

Skip Numbers #3, 7, 9, 17-20 for now.

EQ: Where else in life do we make assumption to simplify a situation?

Agenda

Gas properties and the KMT

Objective(s)

To explain properties of gases using the kinetic molecular theory

To explain to a group of peer one of the tenitis of the KMT of gasses.

Demo

Write on your bellwork what you predict is going to happen

Write down what you actually observed

PhET Gas Law Simulation

Pass it forward, time to turn in

Boyles ($P_1V_1 = P_2V_2$) and Charles Law($V_1/T_1 = V_2/T_2$)

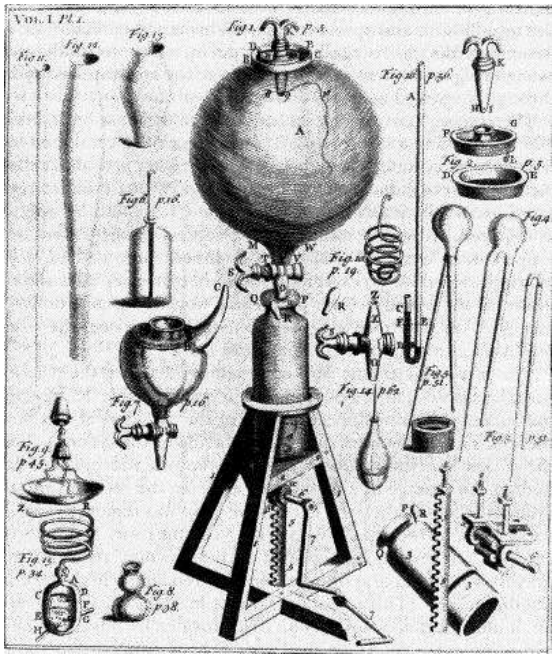
.If a gas at 25.0 °C occupies 3.60 liters at a pressure of 1.00 atm, what will be its volume at a pressure of 2.50 atm?

A gas sample at 40.0°C occupies a volume of 2.32 L. If the temperature is raised to 75.0°C, what will the volume be, assuming the pressure remains constant?

Closure

What are three (3) assumption made in the KMT of gasses regarding gas behavior and properties

Boyle's Law



What is the relationship between pressure and volume if temperature and moles are held constant?

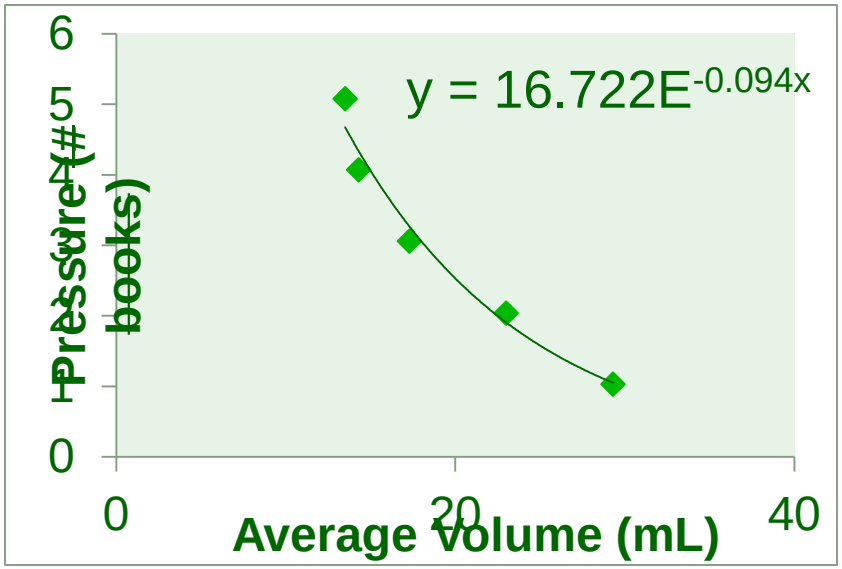
Boyles ($P_1V_1 = P_2V_2$) and Charles Law($V_1/T_1 = V_2/T_2$)

If a gas at 25.0 °C occupies 3.60 liters at a pressure of 1.00 atm, what will be its volume at a pressure of 2.50 atm?

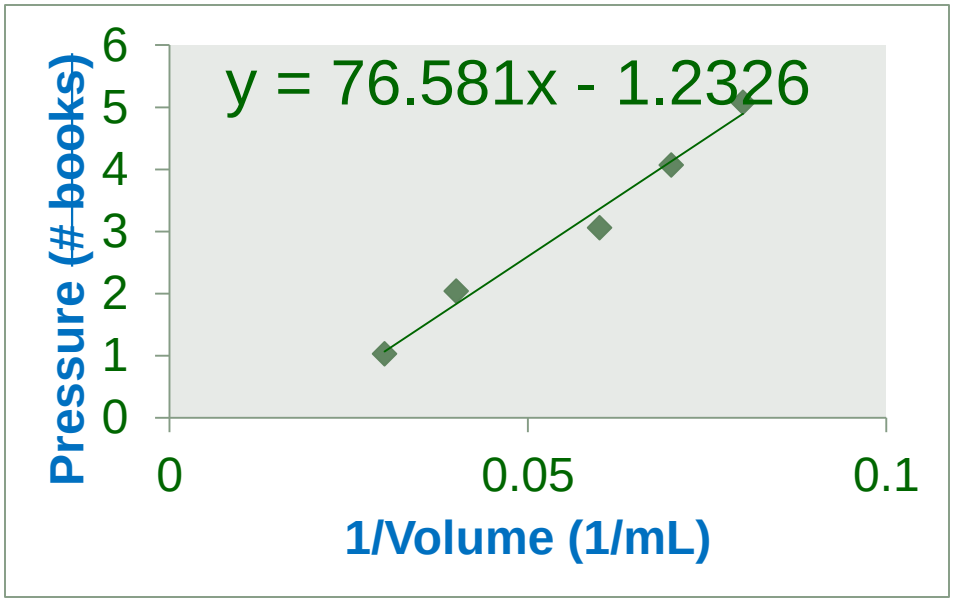
A gas sample at 40.0°C occupies a volume of 2.32 L. If the temperature is raised to 75.0°C, what will the volume be, assuming the pressure remains constant?

Boyle's Law, Data Analysis

Volume v. Pressure



1/Volume v.



When graphing V vs. P the slope is exponential (instantaneous/ not constant) so when we re-graph as V^{-1} vs. P we get a linear slope (constant)

Boyle's Law

In a system in which the amount of gas in a system stays the same and the temperature remains constant:

$$P_1V_1 = P_2V_2$$

P_1 and P_2 must be in the <u>same units</u>

V_1 and V_2 must be in the <u>same units</u>

Now Try This

At STP a sample of nitrogen takes up a volume of 50L. What is the new volume if the pressure is changed to 220 mmHg.

V_2 = ?

P_2 = 220mmHg x $\frac{1atm}{760mmHg}$ = 0.289atm

$P_1V_1 = P_2V_2$

$P_1V_1/P_2 = V_2$

V_1 = 50L

P_1 (STP) = 1atm

(1atm)(50L)/(0.289atm)= V_2

173L= V_2

Elements that exist as gases at 25˚C and 1 atmosphere

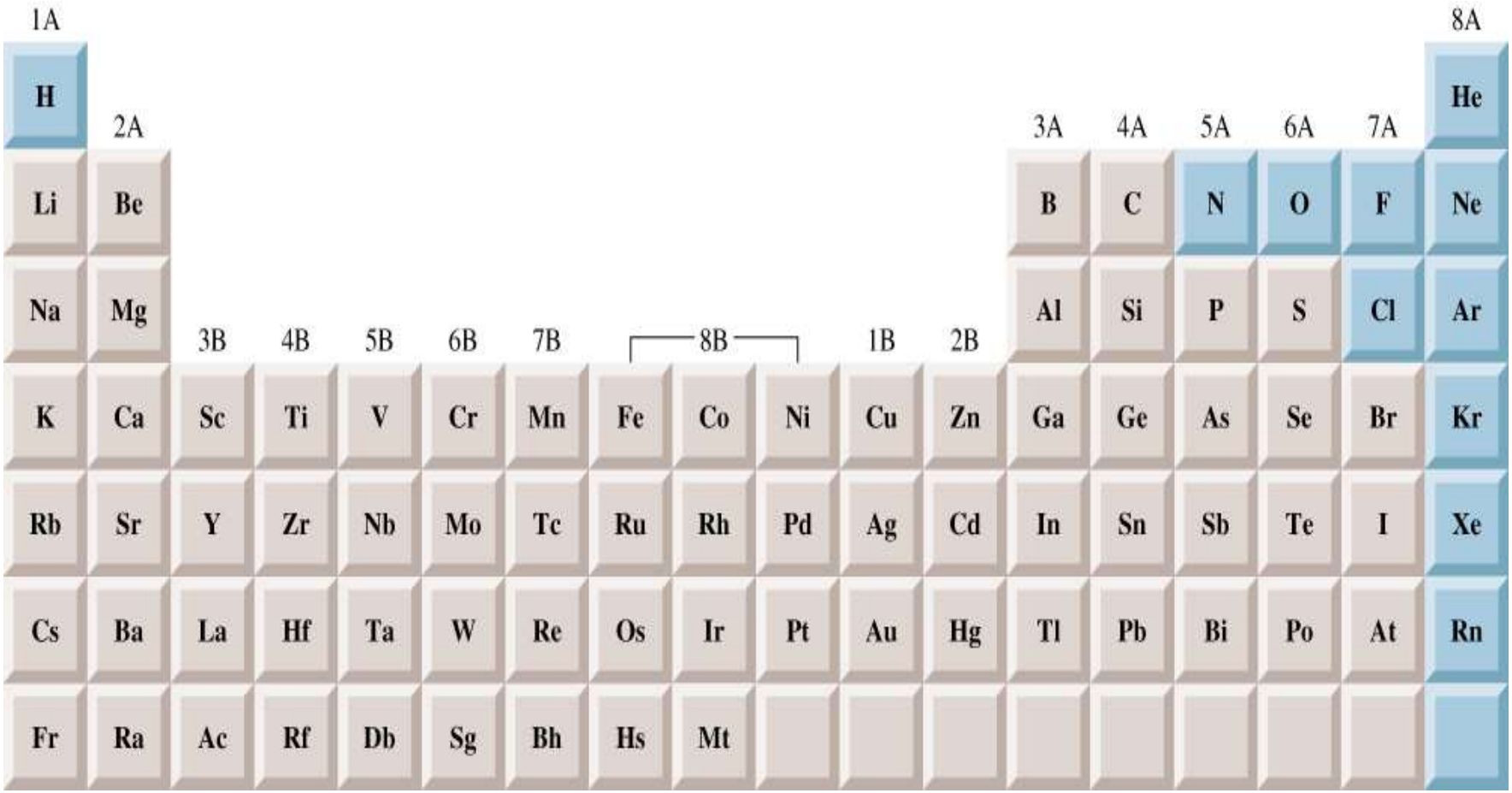


Table 5.1 Some Substances Found as Gases at 1 atm and 25°C

Elements	Compounds
H_2 (molecular hydrogen)	HF (hydrogen fluoride)
N_2 (molecular nitrogen)	HCl (hydrogen chloride)
O_2 (molecular oxygen)	HBr (hydrogen bromide)
O_3 (ozone)	HI (hydrogen iodide)
F_2 (molecular fluorine)	CO (carbon monoxide)
Cl_2 (molecular chlorine)	CO_2 (carbon dioxide)
He (helium)	NH_3 (ammonia)
Ne (neon)	NO (nitric oxide)
Ar (argon)	NO_2 (nitrogen dioxide)
Kr (krypton)	N_2O (nitrous oxide)
Xe (xenon)	SO_2 (sulfur dioxide)
Rn (radon)	H_2S (hydrogen sulfide)
	HCN (hydrogen cyanide)*

** The boiling point of HCN is 26°C, but it is close enough to qualify as a gas at ordinary atmospheric conditions.*

Having a hard time with gas law word problems? Try this…

Problems dealing with only one species and a change in conditions – this set up can help keep track of all variables and values.

Remove the constants, and the remaining variables leaves the correct formula (**Boyles, Charles, Avogadro's, Gay-Lussac's, or Combined**)

1. What you want?

2. Given Information

$P_1 =$ $P_2 =$

$V_1 =$ $V_2 =$

$T_1 =$ $T_2 =$

$n_1 =$ $n_2 =$

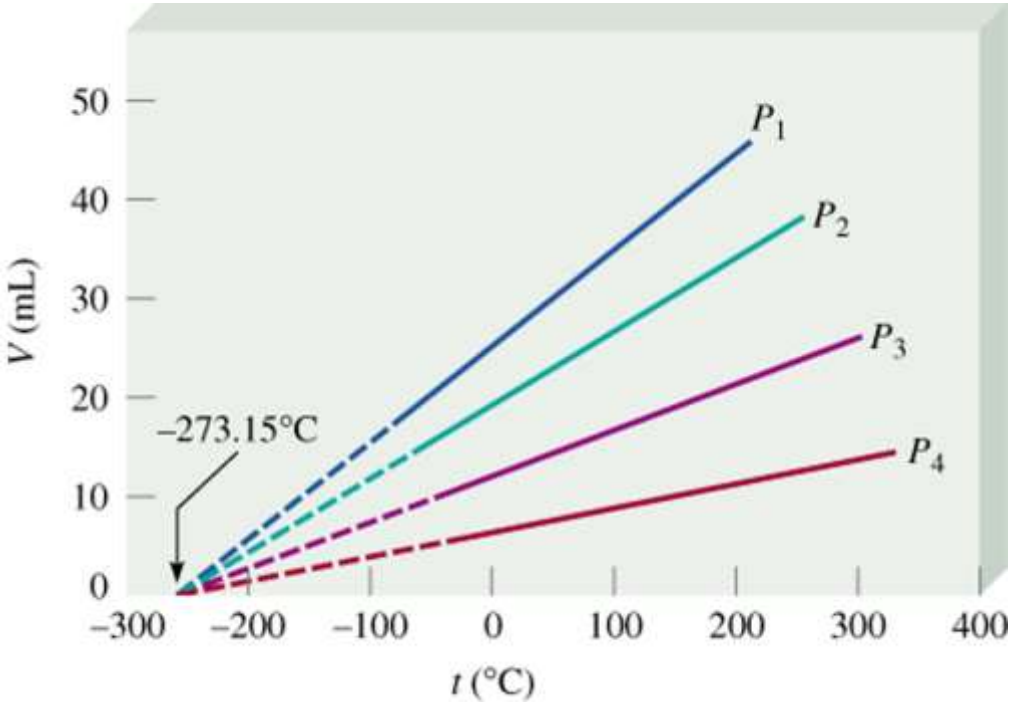
4. Plan

5. Calculations for solutions

3. Useful formulas/ conversions

$$\frac{P_1V_1}{n_1T_1} = \frac{P_2V_2}{n_2T_2}$$

Charles law?



Charles' Law

$$V \propto T$$

$$\frac{V_1}{T_1} = \frac{V_2}{T_2}$$

$$\text{\% Error} = \left| \frac{\text{Theoretical Value} - \text{Experimental Value}}{\text{Theoretical Value}} \right| \times 100$$

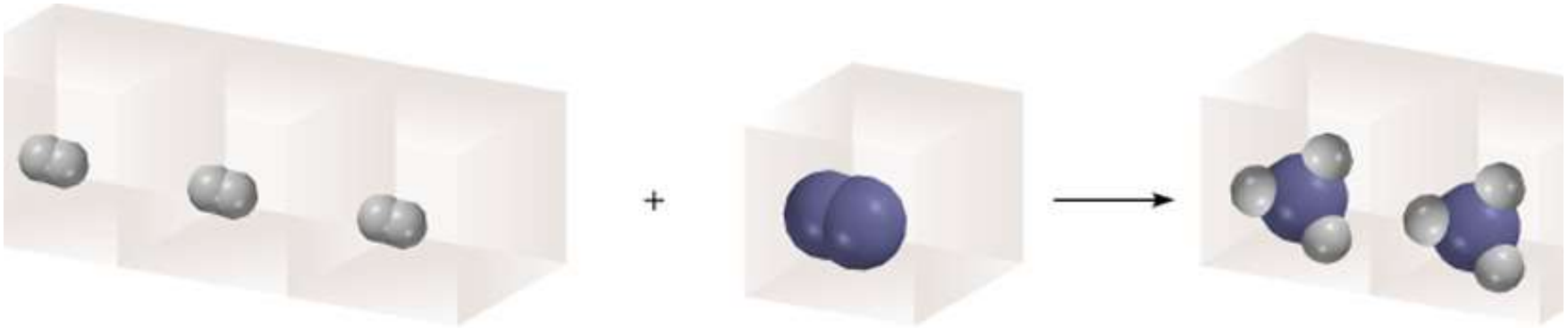
Avogadro's Law

$V \alpha$ number of moles (n)

V = constant x n

Const. Temp.
Const. Pressure

$$\frac{V_1}{n_1} = \frac{V_2}{n_2}$$



$3H_2\ (g)$	+	$N_2\ (g)$	⟶	$2NH_3\ (g)$
3 molecules	+	1 molecule	⟶	2 molecules
3 moles	+	1 mole	⟶	2 moles
3 volumes	+	1 volume	⟶	2 volumes

What do we know so far?

With a constant amount of particles in a sample of gas…

Boyles law

$$P_1 V_1 = P_2 V_2$$

Charles law

$$\frac{V_1}{T_1} = \frac{V_2}{T_2}$$

Gay-Lussac's Law

$$\frac{P_1}{T_1} = \frac{P_2}{T_2}$$

Avogadro's Law

$$\frac{V_1}{n_1} = \frac{V_2}{n_2}$$

How can we put it all together to determine relationships between all three?

6Mar18
Bell Work Using "Box Method"

a. 4.35 L of a gas is at 1.16 atm. What pressure is obtained when the volume is 9.3 L and the temperature remains constant at 25˚C?

b. How is the speed of gas particles related to temperature of the gas. Be sure to describe in terms of E_K (kinetic energy)?

1. What you want?	
2. Given Information	4. Plan
	5. Calculations for solutions
3. Useful formulas/ conversions	

Combined Gas Law!

When the number of gas particles in the system remains constant:

$$\frac{P_1 \times V_1}{T_1} = \frac{P_2 \times V_2}{T_2}$$

Rearrange the equation for:

1. **T_1**
2. **P_2**

KMT

In your assigned pairing (post it note), you have 5-10min to formulate an explanation of the KMT component assigned *and* how it applies to the computer simulation.

Explanation should be 2- 4 sentence written out.

Include a graphic (like a balloon or a box)

You will present this to other students

ACTIVITY!

- Two (2) sets of eight stations
- Two (2) people per station at a time
- One (1) prompt per station
- Three (3) minutes per prompt
- Individual answer sheets on a separate piece of paper

ACTIVITY!

For each situation explain:

1. **What gas properties are being observed (use your notes)**

2. **How do you explain these properties using the KMT (use your notes)**

3. **Give another example in which you observe the same situation**

BellWork 7 Mar 18

On a spring break trip to the lake you attempt to blow up a beach ball when the temp. was at 15°C. Half way through you gave up leaving the beach ball at a volume of only 3.0L. Later in the day you return and the temp. was at 30°C, what happened to the volume of your beach ball assuming pressure and mole remain constant?

a. Describe what happened using KMT and properties of gases.

b. What would be the diameter of the beach ball at the 30°C temperature? ($Vol_{sph} = 4/3\pi r^3$)

c. If the ball weighted 78g and the air inside at 30°C weighted 3.77g what is the density if the air (gas) in g/L?

Bellwork 8Mar18

5.00L of H_2 gas is at a pressure of 877.0 mmHg:

1. What is the pressure of the gas in Pascals?
2. If the volume were increased to18.0L what would the new pressure be in atm?
3. How would the original pressure be different if the gas used was SF_6 instead of hydrogen? **Why?**
4. **Report the air pressure in the room in atm if the meter read 30.07inHg (in = inches, 2.54cm = 1.0in**

https://www.youtube.com/watch?v=1PJTq2xQiQ0

Can Crushing

Using kinetic molecular theory and any of the gas laws we have discussed in class provide a written explanation for why the can had its' structure changed when plunged in cool water?

Can Data

V_1 ____

T_1 ____

P_1 ____

n_1 ____

V_2 ____

T_2 ____

P_2 ____

n_2 ____

Bell Work 8Mar18

1. **Octane (gas) reacts with oxygen to form CO_2(g) and water vapor (see below). If 3,000.0 g of octane is burned how much CO_2 is formed during the reaction?**

$$2C_8H_{18}\,(l) + 25O_2\,(g) \rightarrow 16CO_2\,(g) + 18H_2O(g)$$

a. Solve Boyle's law for P_2.

b. A sample of chlorine gas occupies a volume of 946.0mL at a pressure of 726.0mmHg. What is the pressure of the gas (in mmHg) if the volume is decreased to 154.0 mL?

EQ: After you learn something that was "difficult" why is it now easy?

Agenda

Dalton's Law of Partial Pressures

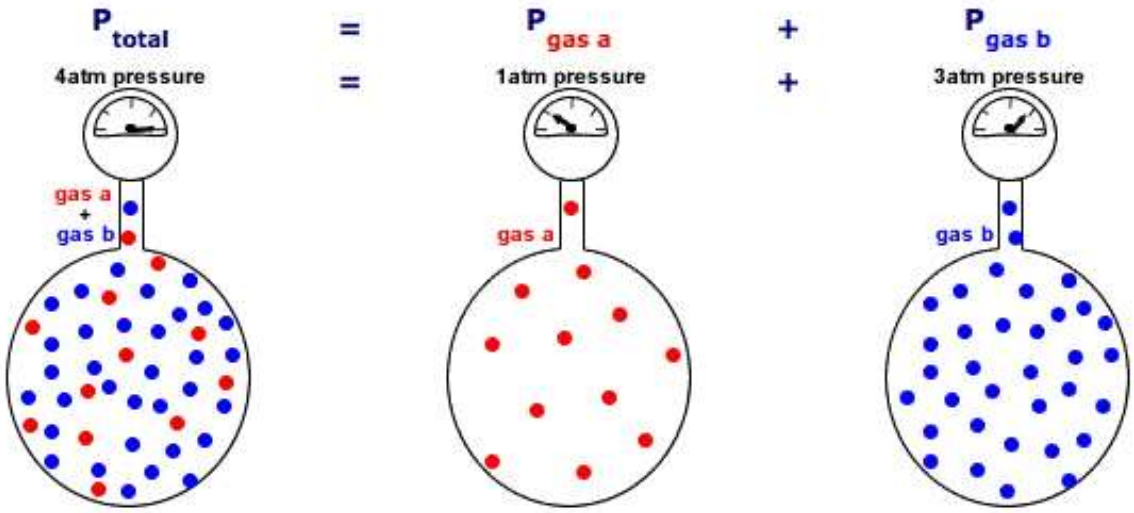
Combined Gas Law/Problem solving box

Objectives

- You will apply Dalton's Law of Partial Pressures and be able to carry out calculations
- You will be able to determine which equation to use given a word problem.

Dalton's Law of Partial Pressures

At a constant volume and temperature the total pressure exerted by a <u>mixture</u> of gases is equal to the <u>sum</u> of their individual pressures



$$P_{total} = P_1 + P_2 + P_3 \ldots P_n$$

Try This

The air around us contains oxygen, nitrogen, carbon dioxide, and trace amounts of other gases. What is the partial pressure of oxygen at 101.3 kPa of pressure if P_{N2} = 79.1 kPa, P_{CO2} = 0.04 kPa, and P_{others} = 0.94 kPa?

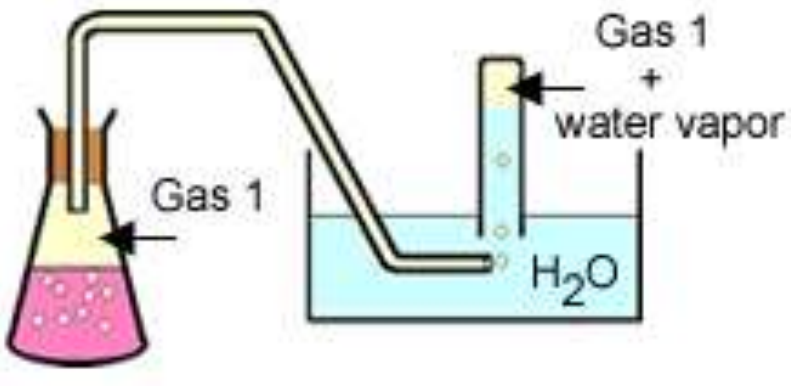
Dalton's Law of Partial Pressures

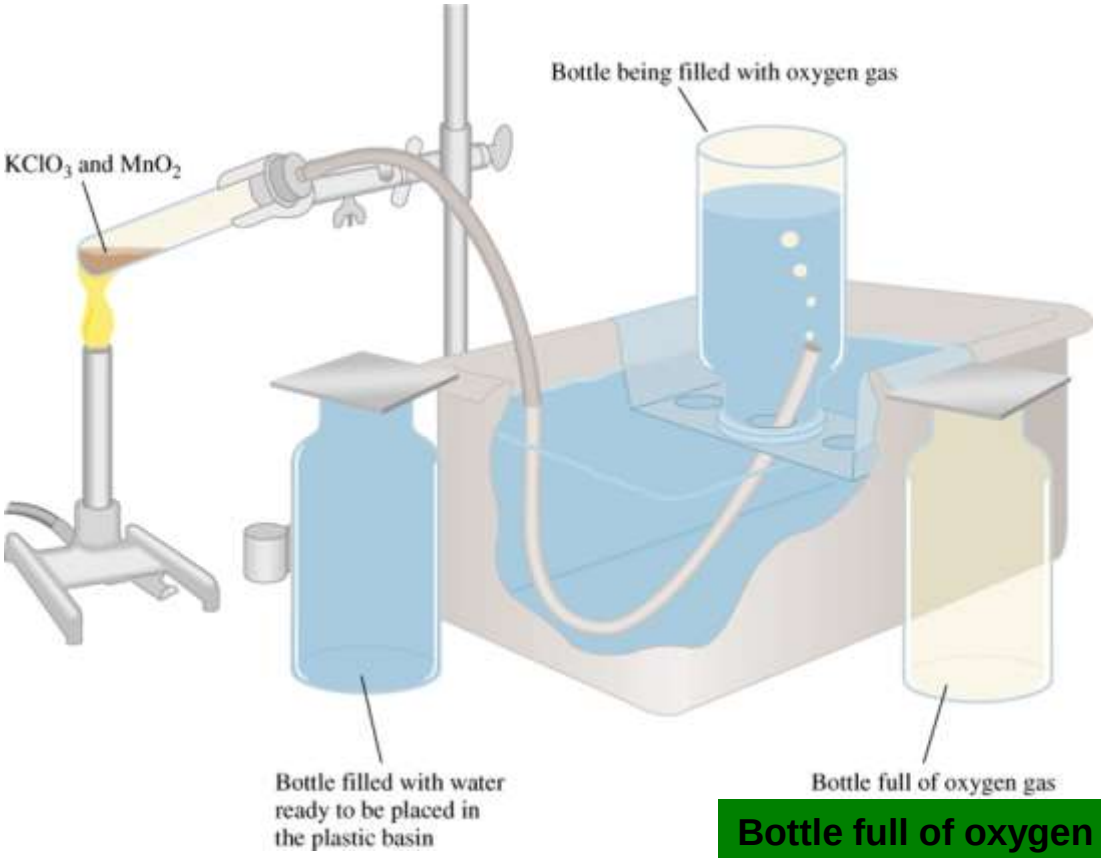
When collecting a gas over water you need to account for the "Vapor pressure" of water at the collection temperature.

To find the pressure of the dry gas alone, we need to subtract out the pressure of the water vapor.

$$P_{total} = P_{dry\ gas} + P_{water\ vapor}$$

$$P_{dry\ gas} = P_{total} - P_{water\ vapor}$$





Bottle full of oxygen gas and water vapor

Table 5.3 Pressure of Water Vapor at Various Temperatures

Temperature (°C)	Water Vapor Pressure (mmHg)
0	4.58
5	6.54
10	9.21
15	12.79
20	17.54
25	23.76
30	31.82
35	42.18
40	55.32
45	71.88
50	92.51
55	118.04
60	149.38
65	187.54
70	233.7
75	289.1
80	355.1
85	433.6
90	525.76
95	633.90
100	760.00

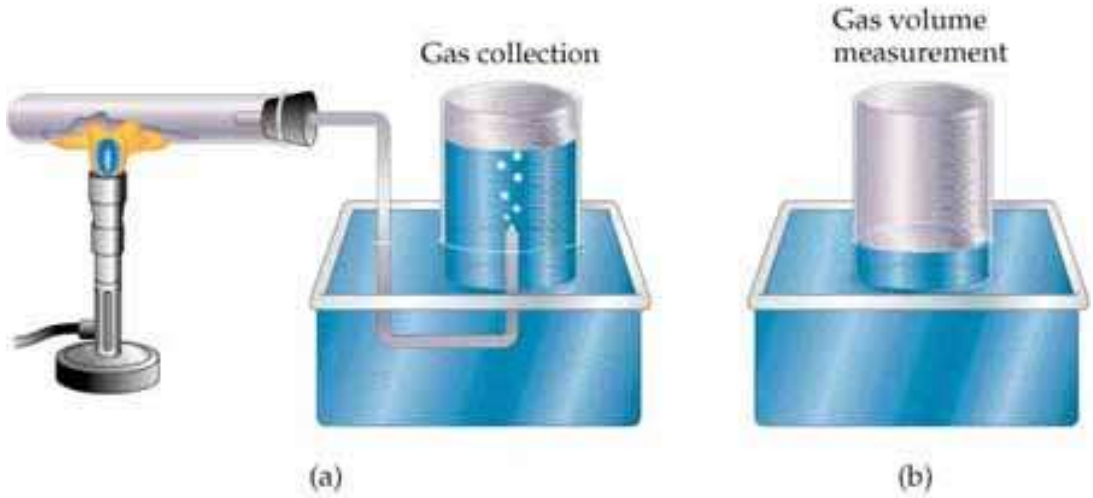
$$2KClO_3\,(s) \rightarrow 2KCl\,(s) + 3O_2\,(g)$$

$$\boldsymbol{P_T = P_{1O_2} + P_{2H_2O}}$$

Dalton's Law of Partial Pressures

A common method of gas collection in the laboratory involves displacing water from a bottle, so that you know when the bottle is full of an invisible gas.

The gas that is left in the bottle will not be pure, it will be a mixture that contains a certain amount of water vapor.



torr = mmHg

Water Vapor Pressure (torr)							
T(°C)	*P*	*T*(°C)	*P*	*T*(°C)	*P*	*T*(°C)	*P*
0	4.58	21	18.65	35	42.2	92	567.0
5	6.54	22	19.83	40	55.3	94	610.9
10	9.21	23	21.07	45	71.9	96	657.6
12	10.52	24	22.38	50	92.5	98	707.3
14	11.99	25	23.76	55	118.0	100	760.0
16	13.63	26	25.21	60	149.4	102	815.9
17	14.53	27	26.74	65	187.5	104	875.1
18	15.48	28	28.35	70	233.7	106	937.9
19	16.48	29	30.04	80	355.1	108	1004.4
20	17.54	30	31.82	90	525.8	110	1074.6

$$1Mg_{(s)} + 2HCl_{(aq)} \rightarrow 1MgCl_{2(s)} + H_{2(g)}$$

$P_{H_2} =$

$V_{H_2} =$

$T_{H_2} =$

$n_{H_2} =$

g

$P_{H_2O} =$

$V_{H_2O} =$

$V_{H_2O} =$

$T_{H_2O} =$

$n_{H_2O} =$

$$P_{total} = P_1 + P_2$$

$$P_{atmpr} = P_{H_2} + P_{H_2O}$$

Dalton's Law of Partial Pressures

A sample of H_2 gas is collected over water at 14.0^{o}C, vapor pressure of H_20 at 14^{o}C is1.6kPa. The pressure of the resultant mixture is 113.0kPa. What is the pressure that is exerted by the dry H_2 alone?

$P_{dry\ gas}$ = ?
P_{total} = 113.0 kPa
$P_{water\ vapor}$ = 1.6 kPa

$P_{dry\ gas} = P_{total} - P_{water\ vapor}$

$P_{H2} = 113.0\ kPa - 1.6\ kPa$

Exit Slip

1. **List the six postulates of the Kinetic Molecular Theory.**

2. **State which one you see at play most in your every day life and give an example of how you see it.**

Bell Work, 13.Mar.18

$2\ Al + 2\ NaOH + 2\ H_2O \rightarrow 2\ NaAlO_2 + 3\ H_2$

We will react 2.0g Al (M.M. 27g/mol) with 10.mL of 6.0mol/L NaOH (MM 40g/mol)...

A. What volume of gas do you expect to be produced at STP (22.4L/mol)?

Table 5.3 Pressure of Water Vapor at Various Temperatures

Temperature (°C)	Water Vapor Pressure (mmHg)
0	4.58
5	6.54
10	9.21
15	12.79
20	17.54
25	23.76
30	31.82
35	42.18
40	55.32

B. What is the partial pressure of the gas if the temp. of the water is 25˚C and the atmospheric pressure in the room is 30.04inHg?

Hint: Daltons Law of Partial Pressure

Word Problem Solving Box

<table>
<tr><td colspan="2">1. What you want?</td></tr>
<tr><td>2. Given Information</td><td>4. Plan</td></tr>
<tr><td rowspan="2">3. Useful formulas/ conversions</td><td>5. Calculations for solutions</td></tr>
</table>

Word Problem Solving Box

Deep sea divers have to use a mixture of gases at depth in order to avoid sickness. If a tank contains 1.60atm of O_2, 0.5atm of He and 2.9atm of N_2, what is the total pressure of the tank?

1. What you want? P_{total}

2. Given Information

P_{O2} = 1.6atm

P_{He} = 0.5atm

P_{N2} = 2.9atm

3. Useful formulas/ conversions

$P_{total} = P_1 + P_2 + P_3$

4. Plan: **Use Daltons law to solve for P_{total}**

5. Calculations for solutions

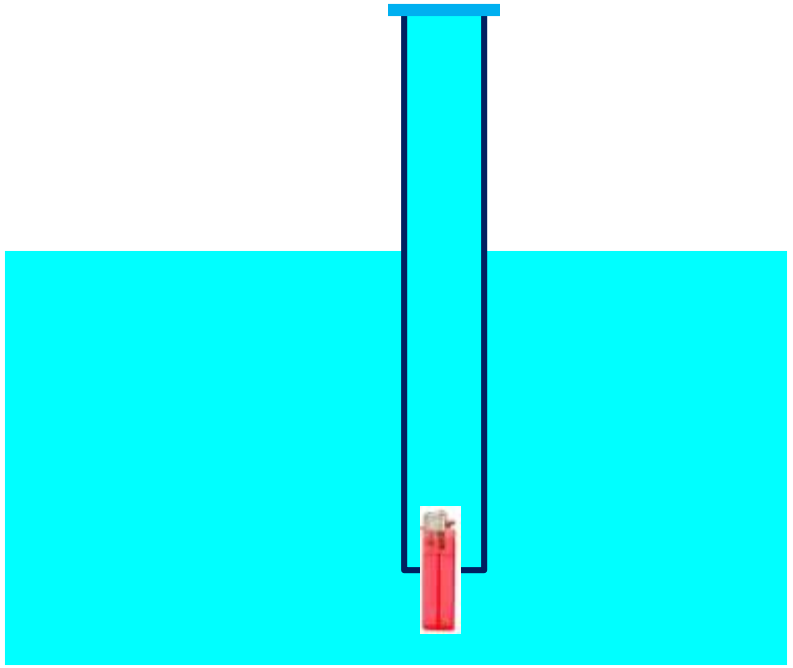
Set Up

12-Mar-2018

Air pressure = _____ inHg

Pick a lighter and record mass to X.XX g

Insure lighter is ***completely dry*** and do not depress gas plunger when drying



$$\mathcal{M} = \frac{dRT}{P}$$

d =

R =

T=

P_{C4H10}=